the pin end **226** of the elongated actuator **210** causes the opposing end **228** having the photometer therein to flex against the touch screen **170**. This flexing may be accommodated by using a flexible or rubber-like material **230** that will return the end **228** back to the position shown in **FIG. 6A** when the pin is no longer being depressed.

[**0044**] Alternatively, **FIG. 7** illustrates the tactile display having built-in touch sensing means in some or all of the individual pixels of the tactile display **104** and an electronic interface for communicating the touch sensing information to the computing device **100**. For example, **FIG. 8** illustrates an actuator assembly similar to FIGS. **6**A-C, except that the individual rods **216** may include strain gauges **232** coupled through a wire **234** to a separate input/output device **155** (See **FIG. 7**) of the computing device **100**. In this latter manner, the touch screen functionality of the touch screen display **170** is effectively bypassed, yet the user would experience a similar touch sensitive interaction with the computer.

[**0045**] Similarly, as shown in **FIG. 9**, one embodiment of the invention would allow direct electronic communication between the tactile display **104** and the computing device **100**. The output communication from the computing device **100** to the tactile display **104** may include attachment of the tactile display to the output of a video card **165**. The video card would provide the dynamic grey scale information required by the tactile display. It should be recognized that in this embodiment, it is no longer necessary for the tactile display device **104** to include an imaging device **102**, such as the photometers **222**. Furthermore, the touch sensing functionality of the tactile display **104**, such as that provided by strain gauges **232** in the individual actuators **210** that comprise the display **104**, may be provided in direct electronic communication with the computing device **100** through an input/output card, such as a mouse port **155**. It should be recognized that this direct electronic communication avoids the necessity of aligning the tactile display **104** with a touch screen display **170**, if any, since no physical interaction such as touching is required. If both the input and output of the tactile display are provided in direct electronic communication with the computing device **100** as just described, then the tactile display **104** can be positioned without regard for the display screen.

[**0046**] **FIG. 10** is a cross-sectional side view of three gel cavities is accordance with a further embodiment of the invention attached to electronic means. Each cavity **324** is cylindrical, with a metallic side wall **318** serving as one electrode and another metal object **322** attached to the floor of the cavity as the other electrode. The gel cavity **324** is about 1.5 mm in diameter and about 1.0 mm in depth. An insulator **316** surrounds the cavity on the surface. The electrode attached to the floor of the cavity is a flat metal disc **322** surrounded by an insulator **320**. A thin elastomeric film **314** tightly seals each cavity, so that the top of each cavity is held generally flat, by its own tension, in the absence of any voltage applied to the electrodes in the cavities. Each of the electrodes **322** attached to the floor of the cavities are attached to line **352** which connects to the video controller **165**. Each of the metallic side wall electrodes **318** are attached to line **350** which connects to the video controller **165**. When voltage is applied to the electrodes in a cavity, the gel in that cavity expands sufficiently to raise a dimple **354** in the elastomeric film. Several polar organic gels are feasible for implementation: poly(isopropylacrylamide), poly(acrylamide), poly(vinyl alcohol), and poly(N-propylacrylamide). These gels are not meant to limit the present invention, and are used only as an illustration to possible implementations.

[**0047**] The gel filling is a small quantity of polar organic gel sensitive to electric fields. Each cavity is individually addressable by electronic means. It is also as easily software-programmable as the bit-mapped video displays currently used by the sighted. This invention therefore can produce large and flexible tactile displays. The use of gel materials to form a tactile display is described in U.S. Pat. No. 5,580,251, which patent is incorporated by reference herein.

[**0048**] As can be seen, the invention may utilize several tactile display means, including mechanical means, electrochemical means, electromagnetic means, and fluid pressure means. For example, a suitable mechanical means includes rods, racks and gears. Suitable electrochemical means includes use of a polar organic gel in combination with electrodes. Exemplary electromagnetic means include an electromagnet causing a pin to move upwardly. Fluid pressure means may include either air or hydraulic fluid moving a pin upwardly. These examples are not meant to limit the present invention in any way. Any tactile display means would be acceptable.

[**0049**] The tactile display means converts the processed electrical signals from the processing means into so-called "tactile images." The tactile images may be felt by a visually impaired person enabling them to ascertain information by touch about the world around them that a sighted person would ascertain through vision. The tactile display means would be accessible for touching by a surface of the individual's body, typically fingertips, and would provide tactile stimulation to the surface of the individual's skin to form a representation of the visual image exposed to the imaging means. For example, if the imaging means were viewing a bar graph having different colors or shades, then the display means would provide a tactile image with each bar having a different height.

[**0050**] In accordance with the present invention, the height of the pixels in the tactile display is variable in proportion to the gray scale intensity of light incident on the imaging means from a visual display screen. The term "gray scale intensity" refers to the magnitude of light per unit area without regard to the actual color. However, as with the gray scale images on black and white televisions, colors are represented as various shades of gray along with white and black. While a gray scale display does not convey as much information as a color display, it is usually sufficient to gain an understanding of the image. This is particularly true in the computer environment where much of the content and information is textual. Even the HTML language uses text as the primary means of navigation through documents and the Internet.

[**0051**] Because the apparatus of the invention senses the gray scale intensity of images, the apparatus is compatible with a wide variety of displays, whether they emit light or merely reflect light. This ability allows the apparatus to work universally with color, monochrome, and LCD displays without customization of the apparatus.

[**0052**] Also, because the apparatus senses the light incident from a visual display, there is no need for the apparatus